A National Program of Research for

SOYBEANS

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES

FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of such joint research planning and was prepared in accordance with recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The Task Force which developed the report was requested to express the collective judgment of individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The Task Force was asked to use the National Program of Research for Agriculture as a basis for its recommendation. However, in recognition of changing research needs it was anticipated that the Task Force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D. C. 20250

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PREFACE

Background

The long-range study, "A National Program of Research for Agriculture," conducted by a joint USDA-SAES Task Force, was published in October 1966. The second recommendation of the study called for a more systematic and continuing mechanism that would facilitate joint research program planning, evaluation, and coordination. The Agricultural Research Planning Committee at its July and December 1966 meetings recommended the establishment of task forces to develop coordinated State-Federal plans for specified areas of research. Subsequently, 32 task forces were established of which this is one.

Authority: The Joint Task Force on Soybean Research, composed of members listed below, was appointed in memoranda of Dr. G. L. Mehren, Assistant Secretary of Agriculture, dated March 24, 1967, and Dr. R. L. Lovvorn, Chairman, Experiment Station Committee on Organization and Policy, dated March 29, 1967.

USDA:
- R. W. Howell, Chief, Oilseed and Industrial Crops Research Branch, Crops Research Division, ARS- Co-Chairman
- J. C. Cowan, Chief, Oilseed Crops Laboratory, Northern Utilization Research and Development Division-ARS
- R. G. Dahms, Chief, Grain & Forage Insects Research Branch, Entomology Research Division, ARS
- E. E. Hartwig, Research Agronomist, Delta Branch Experiment Station, Crops Research Division, ARS
- P. E. Schleusner, Research Management Specialist, Agricultural Engineer, Plant Science Division, CSRS

SAES:
- R. J. Aldrich, Assistant Director, Missouri Agricultural Experiment Station, Co-Chairman
- H. W. Johnson, Head of Department of Agronomy & Plant Genetics, Minnesota Agricultural Experiment Station
- D. R. Kaldor, Department of Agricultural Economics, Iowa Agricultural Experiment Station
- M. W. Phillips, Extension Agronomist, Purdue University
- F. W. Slife, Associate Head of Department of Agronomy, Illinois Agricultural Experiment Station

Consultants:
- P. D. Aines, Food Products Division, Procter & Gamble Co.
- R. W. Judd, Managing Director, National Soybean Crop Improvement Council
- J. Hartz, Jr., Hartz Seed Company

Staff Secy.: Max Hinds, Research Program Development and Evaluation Staff

Assignment: This task force was asked to review and make recommendations with respect to research pertaining to soybeans included in the "National Program of Research for Agriculture" under research problem areas 207, 208, 209, 307, 308, 309, 405, 406, 407, 408, 501, and 504.

SUMMARY

Introduction

The soybean industry:

- ranks 2nd in U.S. cash crops--6th among all agricultural commodities
- U.S. leading nation in soybean production--70% of world production
- soybeans produced in 30 States east of a line from North Dakota through Texas
- in less than a decade acreage almost doubled
- since early 1950's processing capacity has more than doubled
- since early 1950's processing has changed from mechanical crushing to solvent extraction
- two principal products--oil and meal--used in more than 120 different products

Research perspective:

- in 1966, of the total research program, 47% SAES, 53% USDA
- in protection and production research, 64% SAES, 36% USDA
- utilization and marketing research, 12% SAES, 88% USDA
- over the years, cooperative Federal-State relationships have resulted in productive research
- teams of scientists recommended
- increase in research effort early in period recommended

157% increase recommended for entire program

Protection: Goal II

- need to develop varieties resistant to insects and diseases
- need better weed control
- need improved techniques for herbicide application

135% increase recommended for Goal II

Production: Goal III

- increased yield most urgent problem
- need better understanding of plant characteristics, management practices, nutrients, fertilization, energy storage, effects of soil, and growth regulators
- much more can be expected from genetics and breeding--research has barely begun on genetic analysis of numerous traits
- machinery now available poorly adapted for soybeans
- systems analysis needed for better management decisions

231% increase recommended for Goal III

Product Development and Quality: Goal IV

- food products need improvement for consumer acceptance
- need for improved oil stability
- additional opportunities exist for new and improved industrial uses for soybean oil
- more rapid analytical methods needed for computer control of feed formulation using soybean meal
- new techniques, instruments, and procedures needed for detecting contaminants in soybean products
- practical and objective methods needed for determining quality attributes

100% increase recommended for Goal IV

Marketing: Goal V

- many imperfections in marketing system
- low cost, accurate methods for testing oil and protein at county buying points needed
- physical damage, moisture, and mold cause quality deterioration
- new and improved facilities, equipment, and methods of handling needed
- need to evaluate effectiveness of price determination, competition, and consumer attitudes
- need a continuous evaluation of changing relationships between product components and market conditions both here and abroad

40% increase recommended for Goal V

I INTRODUCTION

The charge to the Soybean Task Force was to envision the research needs and opportunities that would best enable the soybean industry to contribute to the public good in the decade ahead. In order to make meaningful recommendations it was useful to develop a brief perspective of the industry's setting in the national economy, including some of the important historical developments.

A. Importance and Scope of the Soybean Industry

The soybean industry ranks second in importance as a U.S. cash crop and sixth among commodity groups. In 1966, the base year used in this report, a comparison of the leading commodities according to their contribution to farm income showed:

Beef cattle and products	20.3%	Soybeans	5.5%
Dairy cattle and products	16.6%	Wheat	4.5%
Poultry and eggs	9.6%	Cotton	3.7%
Hogs	9.5%	Tobacco	2.8%
Corn	6.1%		

World production of soybeans in 1967 was 1.3 billion bushels, almost 1/3 above the 1960-64 average, with most of the gain occurring in the U.S. Four countries produce 95% of the world soybean supply; they are: the U.S., China, Brazil, and U.S.S.R., in that order. In recent years the U.S. has produced 70% of the world supply.

B. Geography of Soybean Production

Agricultural Statistics for 1968 lists soybean production in 30 States. These States encompass the area from New York to North Dakota to Texas to Florida.

C. Historical Trends in the Soybean Industry

1. Trends in Production.--Soybeans have risen from obscurity in the 1930's to second place among U.S. cash crops at the present time. In less than a decade, U.S. soybean acreage almost doubled from 23 million in 1959 to a record 42 million in 1968. Expansion occurred in all areas, with sharp increases in Iowa and in the South. The spectacular increase in soybean production has been due largely to increased acreage. Much of the increased acreage became available for soybean production as a result of policies which limited or discouraged production of other major crops.

With the tremendous increase in soybean production has come great expansion in markets and demand for soybean products--oil and meal. Components from soybeans are used in over 120 different products ranging from livestock and poultry feed to cooking oil and other food products for human consumption, and to plastics and other industrial products.

Recently, soybean production has exceeded the demands for soybeans and soybean products. Stocks on hand September 1, 1968, exceeded those of a year earlier by about 77 million bushels. An additional increase of about 150 million bushels in stocks on hand is forecast for September 1, 1969.

2. Trends in Processing and Product Development.--In the early 1950s soybean processing plants were located mostly in the soybean-corn belt area but by 1967 there were 135 mills located in 23 States. In the early 1950s about 80% of the soybean crop was used domestically and about 20% was exported. From a 1953 production of 269 million bushels 44 million bushels were exported as soybeans and 10 million bushels as oil or meal. By the late 1960s the proportion had changed to about 52% used here and 40% exported. From a 1967 production of 976 million bushels, 285 million bushels were exported as beans and 103 million bushels as oil or meal.

Processing capacity has expanded rapidly, from 310 million bushels in 1951-52 to 750 million in 1967-68. Mechanical methods of crushing soybeans have given way to the more efficient solvent processing.

About 90% of soybean oil goes into such edible products as margarine, shortening, cooking oil, and salad oil. The remainder is used in paints, plastics, coatings, resins, soap, etc. Most of the meal goes into livestock feed; some is used in protein specialties for human consumption.

The development of edible high protein fiber into meatless "meat-like" products has opened the door to new lines of food. Among those now being manufactured are products resembling frankfurters, hamburger, pork sausage, bacon, ham, dried beef, roast beef, fried chicken, and other items. High protein beverages based on soybean protein have been developed in Latin America and Hong Kong.

3. Trends in Marketing.--As soybeans have increased in importance, marketing channels have developed from farmer to country elevator to terminal markets and on to processors and exporters. Soybeans are traded at the Board of Trade in Chicago. Marketing services such as inspection, grading, and price information, have been developed along with market analyses.

D. Research Perspective and Recommendations

The 1966 inventory of agricultural research shown in the Summary Table, page 6, indicates that 131 scientist-man-years (SMYs) were devoted to research pertaining to the soybean industry. The research was conducted by the State Agricultural Experiment Stations (47%) and by the United States Department of Agriculture (53%). The Task Force recommended an increase in this effort to 337 SMYs by 1977, an increase of 157%.

The 1966 research effort by State and Federal agencies in Research Problem Areas (RPAs) related to protection and production was approximately 89 SMY. Of these, 64% were in SAES and 36% were Federal. They are widely dispersed. SAES effort existed in 31 States. No State had more than 5.2 SMY on soybean production research and most of the 31 had less than 2 SMY. ARS effort was located in 14 States, two having more than 5 SMY and four having less than 2 SMY. Historically, the national soybean production research program has developed on a regional basis, stemming from the original authorization in the Bankhead-Jones Act of the mid-1930s. The Federal effort has been and is oriented primarily toward regional objectives. Federal personnel have been stationed in groups in areas where soybean production was expected to become most important. SAES research has increased rapidly in recent years as soybean production has expanded and as local problems have intensified.

The Task Force recognizes the merit of the close association which has existed between USDA and SAES workers and recommends that this relationship be continued as the research program expands. This expansion, at least initially, should be by the development of teams of scientists at selected locations rather than by wide dispersion.

The Task Force is very concerned with the problem of obtaining adequate trained manpower to carry out the recommendations. Concentration at selected locations would help assure maximum utilization of the anticipated scarce manpower resources for the research job already upon us. The USDA and the SAES should keep this in mind in allocating the funds appropriated for this program.

Research objectives in the past have of necessity emphasized regional problems, solution of which would be beneficial over a wide region. This emphasis, wisely established by State and Federal leaders more than 30 years ago, and the concomitant cooperative regional research effort of State and Federal workers, have been of great value in conducting an efficient research program with limited resources. This emphasis on problems of general concern and close cooperation among research workers in all agencies should be continued.

At the same time, it is recognized that soybean production is now beset with problems which must be solved in the context of local production conditions. Many problems involve conditions or interactions which, if not unique, are at least inadequately represented by regional averages. Such problems will increase as soybean production is intensified, and especially as production is extended into new areas and onto new soils.

> Recommendation 1: The Task Force recommends protection and production research effort be distributed in 24 specific objectives within the production RPAs. We expect that the recommended research will produce the technology necessary to raise the national average yield from 25 to 40 bushels per acre. At present acreage and price levels, this would increase farm income $1.5 billion per year by 1977. Research effort should be increased from 89 to 200 SMY by 1972 and to 256 SMY by 1977. Our recommendations are similar to those of the Joint Committee (JC) referred to in the table on page 6, except that we recommend a larger proportion of the increase in RPA 307 and smaller proportions in RPAs 208 and 405. We recommend a rapid increase in research in these areas. The major part of the increase should be sought by 1972 because of the urgency of world food problems. We urge that special concern be given to RPA 105- "Conservation and efficient use of water for agriculture," by the task force on "Water and Watersheds" as the problem pertains to soybeans.

Utilization and marketing research has provided products and markets for most of the soybeans or soybean products produced. Research in these areas should be continued. As production has now exceeded demand, there is a need for increased emphasis on research related to edible and industrial oil products, to identification and elimination of constituents which detract from the quality of soybean products, and to development of new food products which will facilitate use of soybeans in the diets of developing nations. Increased marketing research is needed to insure orderly movement of soybeans and soybean products into the channels of domestic and foreign trade. Now that soybean surpluses have occurred this research takes on additional significance.

Research effort by State and Federal agencies in 1966 in RPAs related to Utilization and Marketing was 42 SMY. Of these, 12% were SAES and 88% were Federal.

Recommendation 2: The Task Force recommends research effort be distributed in eight specific objectives within the utilization and marketing RPAs. We recommend somewhat larger increases in RPAs 406 and 407 related to food and feed products than JC. We also recommend a larger proportion of the increase be sought by 1972 because of the urgency of world food problems. The Northern Utilization Research and Development Division should continue its role as the principal location of utilization research. Expansion of utilization research in SAES should make maximum use of present competence.

Each research problem area assigned to the Soybean Task Force is treated individually in the following sections of this report. The following summary table gives the recommendations of the Task Force in terms of scientist-man-years for each research problem area assigned.

JOINT TASK FORCE ON SOYBEAN RESEARCH

Summary of Inventory and Recommended SMYs

	Research Problem Area	1966[1]			1972[2]			1977[2]		
		SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL
207	Control of Insects	5	2	7	10	4	14(17)	15	6	21(20)
208	Control of Diseases ...	9	13	22	17	19	36	27	25	52(44)
209	Control of Weeds	8	3	11	14	6	20(29)	18	8	26(30)
	Subtotal - Protection .	22	18	40	41	29	70(82)	60	39	99(94)
307	Biological Efficiency .	34	8	42	53	11	64(101)	103	20	123(145)
308	Mechanization[3]						(3)			(3)
309	Systems Analysis				1	2	3 (4)	2	3	5 (4)
405	Consumer Acceptability	1	6	7	3	8	11 (10)	6	10	16(10)
	Subtotal - Production	35	14	49	57	21	78(118)	111	33	144(162)
406	Food Products	2	21	23	3	25	28(38)	4	36	40(44)
407	Feed and Nonfood Products	0	11	11	0	12	12(21)	0	16	16(24)
	Subtotal - Product Development	2	32	34	3	37	40(59)	4	52	56(68)
408	Quality Maintenance ...	1	2	3	1	3	4	2	4	6
501	Grades and Standards[3] ..						(1)			(1)
504	Market Efficiency	2	3	5	2	3	5	2	4	6
	Subtotal - Marketing ..	3	5	8	3	6	9(10)	4	8	12(13)
	GRAND TOTAL	62	69	131	104	93	197(269)	179	132	311(337)

1/ Inventory of Agricultural Research, Volume I, Table I, June 1967.

2/ A joint committee representing the Experiment Station Committee on Organization and Policy and the USDA reviewed manpower allocations and recommended the SMYs shown without parentheses. The SMYs recommended by the Soybean Task Force are shown in parentheses if the Task Force recommendation differed from that of the Joint Committee.

3/ No allocation by commodities in Inventory or Joint Committee recommendation.

II RESEARCH GOALS AND PROBLEM AREAS

A. Protection - Goal II

In the "National Program of Research for Agriculture," the objective under Goal II is to protect forests, crops, and livestock from natural and artificial hazards. Protection of crops requires basic information on insects, diseases, weeds, and environmental hazards that cause losses, and effective economic means for control or elimination of these losses.

This objective was broken down further into 14 research problem areas of which three were applicable to soybeans: RPA 207, Control of Insect Pests of Field Crops; RPA 208, Control of Diseases of Field Crops; and RPA 209, Control of Weeds and Other Hazards to Field Crops.

Many species of insects, numerous plant diseases, and a variety of weeds cause losses to soybeans. Losses are estimated as $75 million from insects, $250 million from diseases, and $400 million from weeds. These estimates include loss in crop value plus cost of control measures now employed. Reduction of these losses would result in immediate benefit to growers and the economy as a whole. The estimated losses do not include potential or actual costs due to pesticide residues or drifts, nor to intangible deterioration of the environment. Recommended control measures for insects and weeds include chemical pesticides as major components of the control systems. Efforts to control diseases through development of resistant varieties have been successful in many cases, but chemicals are also used, especially for seed treatment.

More than 75 chemical pesticides are registered for use on soybeans; many of these are persistent compounds such as chlorinated hydrocarbons. Awareness of the potential hazards of persistent pesticides has increased markedly during recent years. The use of such materials, which may have undesirable and long-lasting side effects, is being resisted in the courts and before regulatory agencies. Present knowledge of dangers which pesticides may impose and the growing public concern over the contribution of pesticides to environmental deterioration only emphasize the need for effective and economical pest control measures which do not involve persistent pesticides.

The Task Force therefore concluded that hazard control research should have a high priority and that such research should be rapidly increased.

NONINSECTICIDAL AND INTEGRATED METHODS OF CONTROLLING INSECTS

RPA 207-A

Situation: Insects cause an estimated $75 million loss to soybeans each year; an additional $12 million is spent on control. An estimated 4 million acres of soybeans are treated with insecticides each year. Public opposition to the use of insecticides continues to intensify. Insecticide residues may occur in the seed, in the oil, or in nontarget crops. Some insecticides are harmful to wildlife or to beneficial organisms, including pollinating insects. Many insects have become resistant to insecticides. Effective control of insects attacking other crops has been attained by integrating use of biological, autocidal, and attractant methods with use of resistant varieties.

Objective: To develop soybean varieties resistant to insects, and determine the chemical, physiological, or morphological nature of resistance; to determine the effectiveness of biological control; to investigate the use of chemical and physical attractants and cultural methods for control; and to develop integrated control programs including minimum use of insecticides.

Research Approaches:

A. Determine the nature of resistance and the inheritance of these factors; collect and evaluate soybean germ plasm for insect resistance, and transfer resistance to adapted varieties.

B. Conduct studies on soybean insect parasites, predators, and disease producing pathogens; develop techniques for quantity production and test these organisms for field control.

C. Conduct tests to determine if the major soybean insects can be sterilized with radiation or chemosterilants.

D. Isolate sex attractants from major soybean insects and determine their feasibility in controlling these insects.

E. Combine these various techniques into integrated insect control systems suitable for use by soybean growers.

Potential Benefits: Reduce cost of production and increase yield and quality.

Recommended Research Effort:

1972	1977
5	6

BIOLOGY OF INSECTS ATTACKING SOYBEANS

RPA 207-B

Situation: Most insects that attack soybeans are native pests that fed on other crops or weeds before soybeans were extensively grown. There is evidence that some of these pests now prefer soybeans to their original host. The decline in acreage of cotton and other crops and increase in soybean acreage has and will continue to cause a change in pest population. The impact of this crop change should be studied to determine its effect upon populations of present pests and potential new pests. The biology of most insects that feed on soybeans has been determined on other host plants but has not been adequately determined on soybeans.

Objective: To determine the occurrence, distribution, abundance, habits, nutritional requirements, and other biological and ecological characteristics of insects attacking soybeans, and utilize this information for the development of chemical, cultural, biological, and other methods for their control.

Research Approaches:

A. Determine the seasonal habits (including mating, feeding, and migration), preference for alternate host plants, and population dynamics of major soybean insects; from this information establish life tables for different ecological areas. All possible sampling methods would be used including mark-release-recapture techniques, light traps, suction machines, sweep nets, directional wind traps, sticky-board traps, pitfall traps, soil washing, and soil sifting equipment.

B. Determine the effect of various insect populations at different times and under different growing conditions on yield and quality of soybeans, and determine the economic injury thresholds.

C. Evaluate the impact of changes in crop sequence and production practices on pest populations and potential new pests.

D. Coordinate research on a regional basis to assure complementarity of related programs.

Potential Benefits: Reduce the cost of production by more efficient use of insect control measures. Reduce residue hazards.

Recommended Research Effort:

1972	1977
8	8

INSECTICIDAL METHODS OF CONTROLLING INSECTS

RPA 207-C

Situation: Insecticides are the first line of defense against insects. Many insects, including some that attack soybeans, have become resistant to insecticides that formerly gave satisfactory control. A continual need for new insecticides to control infestations or sudden outbreaks of insects will exist for the foreseeable future. Recent information has shown that oilseed plants such as the soybean translocate chlorinated hydrocarbon insecticides to the seeds. Soybeans may contain residues of insecticides used on soybeans or on other crops in the rotation. There are no tolerances in soybeans for some insecticides approved for other crops. U.S. tolerances may not be accepted internationally. This is especially critical in soybeans because of the large export market. Some insecticides are phytotoxic to some varieties of soybeans. Some insecticides reduce the population of beneficial parasites and predators and may kill wildlife. New insecticides must be evaluated as they become available to assure their safe use for the intended purpose, and to identify possible undesirable effects.

Objective: To develop cheaper and more effective insecticidal control methods that will leave no objectionable residues in soybeans, cause minimum reduction to beneficial insects, and be nonhazardous to higher animals.

Research Approaches:

A. Evaluate new insecticides for soybean insect control in the laboratory and field.

B. Test various insecticide formulations, rates, and times of application using different types of ground and aerial equipment.

C. Evaluate insecticide effects on beneficial insects and wildlife, and phytotoxicity to different soybean varieties.

D. Determine insecticide residues at harvest in the seed, oil, meal, and forage.

Potential Benefits: Elimination or reduction of insect and residue problems; reduction of residue hazards to health of man and animals; lower cost of insect control.

Recommended Research Effort:

1972	1977
4	6

CONTROL OF DISEASES THROUGH GENETICS AND BREEDING

RPA 208-A

Situation: Soybean diseases increase the hazards of production. Bacterial pustule may reduce yields of susceptible varieties by 8 to 15 percent. Measurable yield reductions from target spot have been obtained with susceptible varieties in 60 percent of the years. These yield reductions have been as high as 50 percent. Phytophthora rot can completely destroy a crop. Brown stem rot is widely distributed. The cyst nematode can cause yield reductions of 50 to 100 percent and root-knot nematodes may cause severe injury. Genetic resistance has been identified for some serious soybean diseases but not for others. The losses due to soybean diseases are estimated to be about $250 million per year.

Objective: To identify sources of resistance to plant pathogens, determine the mode of inheritance, and transfer this resistance to productive, well-adapted varieties.

Research Approaches:

A. Observe available germ plasm for reaction to pathogens.

B. Study inheritance of host reaction to pathogens.

C. Conduct breeding programs to transfer resistance to productive, well-adapted varieties.

Potential Benefits: Hazards of production will be reduced, seed yields increased, and seed quality improved.

Recommended Research Effort:

1972	1977
16	20

CROP SEQUENCE AND MANAGEMENT PRACTICES TO REDUCE INCIDENCE OF SOYBEAN DISEASES

RPA 208-B

Situation: Continuous cropping is known to increase the injury to soybeans resulting from cyst nematodes and brown stem rot. Crop rotation aids in control of these diseases. However, rotation with cotton increases the severity of injury from target spot and root-knot nematode. Crop sequence appears to have little influence upon injury from phytophthora rot. Certain weed species are believed to be carriers of viruses which infect soybeans. Methods of tillage and sanitation are effective in controlling certain diseases on other crops. Chemical control measures are of minor significance.

Objective: To study disease development on soybeans under different crop sequence systems, methods of tillage, and weed control programs, and to develop management practices to reduce losses due to diseases.

Research Approaches:

A. Study effectiveness of different crop sequences, planting patterns, and methods of seedbed preparation in controlling the principal soybean pathogens.

B. Determine alternate crops and weeds which may serve as hosts for soybean pathogens, and the effect of herbicides and other weed control practices on soybean diseases.

C. Study the effect of various cropping procedures and management practices on the soil microorganism balance in relation to soilborne pathogens.

D. Test chemical agents for systemic or localized control of diseases and develop techniques for the effective use of such agents.

Potential Benefits: Determination of the significance of changing crop sequence patterns in the incidence and control of soybean diseases; evidence of advantages and disadvantages of monoculture; identification of other plant species which may be significant in prevalence of soybean diseases.

Recommended Research Effort:

1972	1977
5	8

THE ROLE OF INSECTS IN TRANSMISSION OF SOYBEAN VIRUSES

RPA 208-C

Situation: Several virus diseases such as soybean mosaic, bean pod mottle virus, tobacco ring spot virus, and yellow mosaic occur in soybeans. Soybean mosaic and bean pod mottle viruses when present together cause significant yield losses. Tobacco ring spot virus has caused complete loss through failure of seed set in localized areas. Other viruses may occur but have not been investigated. Insects are by far the most important agents of virus transmission. Soybean mosaic is transmitted by aphids, and bean pod mottle virus is spread by bean leaf beetle. Leafhoppers are suspected as a transmitter of tobacco ring spot virus but no vector has been positively identified. Spider mites are widely distributed and may transmit viruses.

Objective: To determine the role of insects and mites in the transmission of soybean diseases and use this information as an aid to control the disease.

Research Approaches:

A. Use various mites and insects, especially aphids and leafhoppers, collected in virus-infected soybean fields, in transmission tests to determine if they are vectors of soybean viruses.

B. Determine virus movement and increase within the vector.

C. Determine the relationship of vector movement between and within fields to the spread and incidence of viruses.

D. Exclude certain suspected vectors from areas within fields of soybeans having virus problems to observe virus development and spread in the absence of insects and the effect of vector control on the incidence and spread of viruses.

Potential Benefits: Reduced yield losses from virus diseases; improved seed quality.

Recommended Research Effort:

1972	1977
2	2

LIFE HISTORIES OF SOYBEAN PATHOGENS AND LOSSES FROM SOYBEAN DISEASES

RPA 208-D

Situation: Numerous plant pathogens are known to attack soybeans. Pathogens frequently appear in combination. The interrelationships are not fully understood. Information on life histories of pathogens as they relate to soybean diseases is essential for an efficient control program. Estimates of yield reductions have been made for bacterial pustule, target spot, cyst nematodes, and phytophthora rot. Yield reductions may range from slight to complete destruction. Additional pathogens are frequently recognized but estimates of yield reduction have not been made. Disease loss estimates have not been made with adequate consideration of other limitations on production, nor of the interaction of production level and economic factors. Reliability of estimates of losses in a small plot is much greater than estimates of total losses from soybean diseases on a nationwide basis.

Objective: To gain a more thorough understanding of pathogens attacking soybeans, their effects upon the efficiency of the soybean plant, and the nature and extent of losses due to soybean diseases.

Research Approaches:

A. Identify pathogens and determine host range and environmental factors favoring their development.

B. Study life cycles of pathogens to identify stages which offer good opportunities for control.

C. Study genetic and environmental variability of pathogens.

D. Use closely related resistant and susceptible soybean strains or chemical control to determine the nature and extent of losses caused by soybean diseases alone, in combination, and under various environmental and management situations.

E. Develop effective inoculation techniques to facilitate studies of injury and control methods.

Potential Benefits: The benefits from this activity are related directly to those from breeding and management. The information obtained will facilitate and speed the gains obtained in the other activities and may prevent losses that would occur in the absence of the information.

Recommended Research Effort:

1972	1977
12	12

IDENTIFICATION AND CONTROL OF FOREIGN DISEASES THAT MAY DAMAGE SOYBEANS

RPA 208-E

Situation: Many of the plant pathogens known to attack soybeans in Asia have not appeared in U.S. soybean-growing areas. The reaction of U.S. germ plasm to some of these pathogens is not known. A devastating disease such as a rust could cause losses of hundreds of millions of dollars per year.

Objective: To determine reaction of major U.S. soybean varieties and germ plasm to foreign disease organisms and to better understand the potential damage that could result from introduction of such soybean pathogens.

Research Approaches:

A. Screen U.S. varieties for reaction to pathogens in areas where diseases are now found.

B. Study nature of disease and its incitant in areas where it is a problem.

C. Initiate a breeding program, in cooperation with foreign scientists, to develop resistant lines for U.S. areas where disease is most likely to be a problem.

D. Participate in the International Biological Program in order to obtain maximum effectiveness of international programs.

Potential Benefits: Minimize potential effects upon U.S. soybean production of introduction of new pathogens. Understanding a disease such as soybean rust and having resistant genotypes identified prior to introduction of the pathogen could prevent losses due to new diseases.

Recommended Research Effort:

1972	1977
1	2

PRINCIPLES AND PRACTICES TO CONTROL SPECIFIC WEEDS IN SOYBEANS

RPA 209-A

Situation: The weed flora in soybeans differs not only from area to area, but may differ from farm to farm. A weed control program for one soybean grower may not be suitable for his neighbor because of different weed species, different soils, different crops, and different equipment availability. More effective weed control could be achieved with better information on control of specific weeds as it is affected by cropping practices, cultural practices, and crop-chemical interactions.

Objective: To determine the most adequate system of cultural, biological, and chemical control practices for specific weeds in soybeans.

Research Approaches:

A. Study cropping sequences to determine the effect of various practices on the weed population.

B. Develop combinations of cropping sequences, herbicides, and cultural practices for specific weed situations.

C. Exploit the results of research described in RPA 209-B, -C, -D, -E, and -F, which is essential for achievement of the objective of this RPA.

D. Coordinate with research in RPAs 307 and 308.

Potential Benefits: Increase soybean yields by reducing weed competition. Make available to the soybean grower information needed to select the best weed control system for his specific situation.

Recommended Research Effort:

1972	1977
3	4

MECHANISM OF ACTION OF SOYBEAN HERBICIDES

RPA 209-B

Situation: Soybean herbicides have been developed from rather massive screening programs by chemical companies. Better herbicides are needed for soybeans. Present pre-emergence compounds fail about one-third of the time thus allowing weeds to compete with soybeans. Herbicides sometimes injure soybeans or increase their susceptibility to diseases. Post-emergence herbicides are generally injurious to soybeans. A better understanding of the mechanism of herbicide action would facilitate development of new and better herbicides.

Objective: To determine the mode of action of soybean herbicides and to use this information in developing new chemicals and improving old ones.

Research Approaches:

A. Determine the effects of soybean herbicides on various metabolic systems in weed and crop plants.

B. Determine genetic variability in tolerance to herbicides among soybean genotypes, and the feasibility of improving weed control by breeding soybean varieties with herbicide tolerance.

C. Develop and test theories, based on results of A, to explain herbicide action and selectivity.

D. Use information from A, B, and C to design and search for new and more effective weed control compounds.

Potential Benefits: Synthesis of safer and more effective soybean herbicides. A satisfactory post-emergence chemical could eliminate weed control failures due to weather and reduce the cost of weed control.

Recommended Research Effort:

1972	1977
6	6

APPLICATION TECHNIQUES TO IMPROVE HERBICIDE PERFORMANCE IN SOYBEANS

RPA 209-C

Situation: A rather large group of promising herbicides are not used in soybeans because suitable application techniques are lacking. Some of these materials are volatile, and hence may disappear too rapidly or may affect nearby sensitive crops. Some are nonselective and may damage soybeans, but might be useful if applied as directed post-emergence sprays or pre-plant treatments. In addition new incorporation techniques may improve the performance of presently used chemicals.

Objective: To improve weed control in soybeans by studies on various chemical application techniques.

Research Approaches:

A. Determine the most effective means of applying volatile and nonvolatile weed control chemicals (incorporation at planting, injection devices, preplant incorporated treatments, etc.) This would include a study of chemical additives for drift control.

B. Develop application techniques for nonselective chemicals in soybeans, to include evaluation of preplant treatments and various directional devices to maximize weed control and minimize soybean injury.

C. Coordinate with research in RPAs 307 and 308.

Potential Benefits: Improved weed control practices for soybeans by increased efficiency from present weed chemicals; development of techniques to make available new soybean herbicides.

Recommended Research Effort:

1972	1977
5	5

LIFE HISTORY OF SPECIFIC WEEDS COMMON TO SOYBEAN FIELDS

RPA 209-D

Situation: There has been very little study of the physiology, anatomy, and morphology of most weed species. Thorough study of the life cycle of annual and perennial weeds may reveal stages of growth at which chemical or cultural control would be most effective. The ultimate weed control practice is one which would lead to the destruction of weed seeds in the soil. Studies of seed dormancy and methods of breaking dormancy could lead to better control of the seeds in the soil.

Objective: To determine stages in the life cycles of annual and perennial weeds where control measures would be most effective.

Research Approaches:

A. Determine the growth patterns and relative competitiveness of weeds in relation to soybean varieties from germination to maturity.

B. Determine physiological and anatomical characteristics of specific weeds and evaluate these characteristics as means of controlling weed growth.

C. Study the nature and extent of weed seed dormancy in various species and develop methods to alter dormancy. Particular emphasis would be placed on the time and extent of germination in relation to soil temperatures.

Potential Benefits: Better timing of cultural weed practices or chemical treatments; more effective use of weed control measures through control of dormancy of weed seeds.

Recommended Research Effort:

1972	1977
4	4

HERBICIDE SPECIFICITY, SELECTIVITY, AND INTERACTION WITH OTHER CHEMICALS IN RELATION TO SOYBEAN PRODUCTION

RPA 209-E

Situation: During the past 20 years a large number of chemicals have become available for weed control. Many of these have not been critically evaluated for minimum levels of toxicity to individual weed species nor for tolerance by soybeans. Many herbicides are used without adequate information on specificity of the herbicide. Some soybean growers are using fungicides and insecticides in addition to herbicides. The interaction of these materials needs to be studied.

Objective: To determine minimum effective and toxic levels of herbicides and develop combinations of pesticides for more efficient weed control.

Research Approaches:

A. Determine the minimum rate of specific herbicides needed to kill individual weeds in soybeans.

B. Determine the effect of herbicide, insecticide, and fungicide combinations on pest control, soybean growth, *Rhizobium* activity, and diseases.

C. Develop combinations of chemicals for broader spectrum weed control in soybeans and better soybean tolerance to herbicides.

Potential Benefits: Lower yield losses in soybeans caused by weeds, improved performance of herbicides, and better information on which soybean growers may base their selection of herbicides and other pesticides.

Recommended Research Effort:

1972	1977
6	6

SOIL AND PLANT RESIDUE EFFECTS IN RELATION TO SOYBEAN PRODUCTION

RPA 209-F

Situation: A number of useful herbicides leave residues in the soil that may affect soybeans. The fate of herbicides in soils and soybeans needs to be determined to prevent injury to the soybean plant and contamination of the environment.

Objective: To determine the fate of herbicides applied to the soil for weed control in soybeans and other crops and to identify potential hazards to soybean production.

Research Approaches:

A. Analyze soil and plant materials to determine levels of herbicide residues under different environmental conditions.

B. Determine chemical derivative residues of herbicides in soils or plant materials.

C. Determine properties of derivative residues such as toxicity, volatility and solubility.

Potential Benefits: Prevention of losses due to stand loss and plant injury to soybeans and other crops planted on fields previously treated with herbicides; reduced possibility of contaminating crop products.

Recommended Research Effort:

1972	1977
5	5

B. Efficient Production of Farm and Forest Products - Goal III

In the "National Program of Research for Agriculture" the objective under Goal III is the production of an adequate supply of farm and forest products at decreasing real production costs. The objective was further broken down into 16 research problem areas of which three were applicable to soybeans: RPA 307, Biological Efficiency of Field Crops; RPA 308, Mechanization of Production of Field Crops; and RPA 309, Systems Analysis in Production of Field Crops.

In addition, RPA 405, Production of Field Crops with Improved Consumer Acceptability, which is in Goal IV, "Product Development and Quality," is discussed in this section of the report.

Policies and attitudes concerning production of various crops are changing. To a greater extent than in the past, the farmer will compare the potential profit of a soybean crop with that of some other crop or enterprise. Soybeans probably will not maintain their present acreage and production level unless unit production costs are lowered. This may be achieved by more efficient production practices. However, increased yields offer the greatest opportunity for lowering unit costs because much of the production cost is relatively inflexible on an area basis.

It is important to the national welfare and to the food needs of a hungry world that a high level of soybean production be maintained. Soybean protein is a major resource in the fight against hunger. Because of the high protein content and excellent protein balance of soybeans, increases in soybean yields are immediately effective in improving the world protein situation. For example, an increase of only one bushel per acre in soybean yields on 40 million acres would increase protein supplies by 480,000 tons. This is quantitatively equivalent to the annual protein needs of 17 million people. As a supplement to other sources of protein, it would benefit a vastly larger number.

It is, therefore, the judgment of the Task Force that the most urgent problem facing soybean research workers is the need for increased yield per acre.

PLANT CHARACTERISTICS AND MANAGEMENT PRACTICES

RPA 307-A

Situation: Soybean genotypes apparently differ in efficiency of use of water and other elements of the environment. Strains of similar growth type and maturity may produce comparable yields with adequate moisture, but significantly different yields under conditions of stress. Dates and rates of planting, row width, rotation sequences, growth habit, root penetration, and other factors interact with the environment.

Objective: To determine the attributes which permit soybeans to make most efficient use of water and nutrients in producing maximum seed yields; to identify management practices which will result in more uniform stands, deeper root penetration, and maximum response to available moisture and nutrients.

Research Approaches:

A. Evaluate time and methods of planting, and methods of seedbed preparation in relation to crop productivity and the ability of plants to utilize available water or respond to application of water.

B. Evaluate plant characteristics to identify those which contribute to most efficient water and nutrient use in producing high seed yields at different levels of water and nutrient availability, including extremes--excesses or deficiencies.

C. Evaluate genotype-environment interactions under various moisture levels and soil types.

D. Coordinate with weed studies in 209-A, fertility, nitrogen, and root studies in 307-B, -D, and -E, and engineering studies in 308.

Potential Benefits: Hazards of production will be reduced and higher yields of good quality seed obtained. More efficient water use could result in an average yield increase of 1 bushel per acre.

Recommended Research Effort:

1972	1977
8	12

We recommend that the task force on Water and Watersheds, give special thought to soybeans in its consideration of RPA 105, Conservation and Efficient Use of Water for Agriculture.

NUTRIENT RELATIONSHIPS AND FERTILIZATION OF SOYBEANS

RPA 307-B

Situation: The failure of direct soybean fertilization to consistently increase yields is one of the major factors limiting soybean production today. Yield increases can be expected from the application of phosphorus and potassium when availability of these nutrients in the soil is low, but failure to obtain a response at medium or high soil fertility levels is common. Soybeans respond to micronutrients on some soils, but areas of deficiencies are not well identified. A pH of 5.8 to 6.5 is desirable for soybean production. Liming changes the pH of the surface soil but has little influence on the subsoil pH. As a result, aluminum toxicity may limit root development in highly acid subsoils, and thus contribute to drouth stress, reduced nutrient uptake, and lower yields.

Objective: To understand the mineral nutrition of soybeans so that response to direct fertilization can be assured; to determine whether macro- or micronutrients are limiting seed yields under conditions considered to be optimum for seed development; to determine the effects of low pH subsoils upon root development and water and nutrient uptake, and if detrimental to the plant, develop corrective methods.

Research Approaches:

A. Determine nutrient concentrations in the total plant and plant parts which define and separate deficiency, adequacy, and luxury levels of essential nutrients at different growth stages.

B. Obtain specific information on: (1) nutrient interactions that influence plant growth and final yield, (2) nutrient uptake rates at various stages of growth, (3) translocation of nutrients within the plant, and (4) genetic variability in expression of these factors.

C. Study the influence of acid subsoils on root penetration and nutrient and water uptake under varying moisture situations, at different surface soil pH levels, and with soybean genotypes differing in sensitivity to aluminum.

D. Coordinate with water, nitrogen, and root studies in 307-A, -D, and -E, and engineering studies in 308.

Potential Benefits: Increased soybean yields through greater responses to fertilization and development of methods for estimating nutrient requirements at specific stages of growth.

Recommended Research Effort:

1972	1977
14	19

MORE EFFICIENT ENERGY STORAGE BY SOYBEANS

RPA 307-C

Situation: The major problem in soybeans is low yields. Photosynthesis in single leaves is saturated by a light intensity about one-third that of full sunlight. The closed canopy in soybean fields lowers light intensities on some leaves to as little as 100 foot candles. At this intensity, the rate of photosynthesis hardly exceeds that of respiration. Furthermore, soybeans have a photo-respiration mechanism capable of oxidizing unproductively a substantial portion of the organic carbon produced in photosynthesis. Present techniques for studies of photosynthesis, lipid metabolism, protein synthesis, translocation, and other aspects of plant metabolism, and for measurement of light and carbon dioxide, are adequate for detailed studies of the significance of these processes to soybean yields.

Objective: To identify genotypes combining improved energy storage with other desirable attributes and develop management practices which will increase the conversion of absorbed light energy to chemical energy and the storage of energy in the seed.

Research Approaches:

A. Determine the significance of variability in anatomical details due to genetic or environmental causes to the absorption of carbon dioxide, the conversion of light energy to chemical energy, and the storage of energy in soybean seed.

B. Identify details of photosynthesis and related processes which may contribute to a more efficient energy storage.

C. Determine the total energy demands of metabolic systems synthesizing fat and protein, and evaluate the significance of these demands to total energy storage.

D. Determine the genetic variability of significant anatomical, metabolic, or other factors.

E. Develop management practices to provide maximum absorption of carbon dioxide and light.

Potential Benefits: Increased soybean yields.

Recommended Research Effort:

1972	1977
10	12

NITROGEN NUTRITION

RPA 307-D

Situation: Soybean yields from very high levels of nitrogen fertilization have not exceeded those obtained with good nodulation. Very little information is available relative to growth promoting substances other than nitrogen that might be produced in the nodule. One strain of Rhizobium japonicum is known to produce a chlorosis-inducing toxin. Present information is not sufficient to permit productive manipulation of the nitrogen nutrition of soybeans by fertilization as can be done with many other crops.

Objective: To develop methods of increasing nitrogen utilization by the soybean plant so as to obtain higher seed yield.

Research Approaches:

A. Ascertain the maximum yield possible with nitrogen from nodulation and whether soybean yields are limited by inadequate nitrogen from nodulation.

B. Characterize nitrogen fixation in the nodule and the metabolic steps required to convert fertilizer or fixed nitrogen to forms stored in the plant.

C. Ascertain the variability among strains of nodulating bacteria in efficiency of nitrogen fixation and the significance of interactions among genotypes of bacteria and genotypes of soybeans.

D. Develop inoculation procedures that will permit improved strains of bacteria to be introduced into the soil and utilized by the plant in preference to indigenous strains.

E. Ascertain the relationships of strains of bacteria with other microorganisms in the soil in relation to survival of strains of rhizobia.

F. Coordinate with water, fertility, and root studies in 307-A, -B, and -E, and the engineering studies in 308.

Potential Benefits: Increased soybean yields.

Recommended Research Effort:

1972	1977
10	11

ROOT-SOIL RELATIONSHIPS

RPA 307-E

Situation: Soybean yields obtained by good managers often vary 20 to 40 percent between fields on the same farm. This variability is assumed to be due primarily to conditions existing below the soil surface.

Soil moisture, air, temperature, mechanical impedance, and microbial activity influence root and plant development. Vegetative growth and seed production are affected by the distribution and function of the roots. The biochemical activities of the rhizosphere population have not been sufficiently defined for evaluation of effect on seed production. The effect of root exudates on soil microorganisms and on the uptake and translocation of nutrients is poorly understood. Since optimum soil properties are not known, modification of soil factors for maximum soybean seed production must be determined empirically.

Objective: To determine means of improving the soybean root system and root environment to increase efficiency in water and nutrient uptake.

Research Approaches:

A. Characterize soybean root growth, development, and function under various conditions and determine if genetic differences in total root growth affect seed yield.

B. Determine optimum soil-water conditions for soybean root development.

C. Determine if nutrient uptake is directly correlated with the formation of new root structure and if a longer period of root development will contribute to higher seed yield.

D. Investigate microbial activities in the rhizosphere and the role of root exudates.

E. Coordinate with water, fertility, and nitrogen studies in 307-A, -B, and -D, and the engineering studies in 308.

Potential Benefits: More efficient use of water, nutrients, and oxygen; increased seed yield.

Recommended Research Effort:

1972	1977
11	17

GENETICS AND BREEDING FOR HIGHER YIELD

RPA 307-F

Situation: The success of soybean production in the United States can be attributed largely to use of improved varieties resulting from genetics and breeding research. Much more can be accomplished in this field. Research has barely begun on the genetic analysis of numerous traits ranging from gross morphology, such as determinate vs. indeterminate growth, to physiological responses, energy storage, and water or nutrient use. Complete utilization of information on basic physiological processes to improve seed yield and seed quality depend in large part on research in genetics and breeding.

Objective: To develop through breeding higher yielding soybeans which have desired market qualities.

Research Approaches:

A. Ascertain the inheritance of basic physiological differences.

B. Investigate the interactions between genotypes of the soybean and genotypes of nodulating bacteria to determine the extent that improved combinations can be developed and utilized.

C. Investigate the influence of protein and oil content and of amino and fatty acid balance on seed yield, and incorporate the desired qualities into productive varieties.

D. Develop more efficient genetic combinations with multiple disease resistance, tolerance to pesticides, and responsiveness and efficiency in utilization of water, light, and nutrients.

E. Investigate methods of breeding; identify ways to increase gain per breeding cycle and reduce the time for each cycle.

Potential Benefits: Improvement in genetic potential for yield. Development of types varying in protein and oil relationship could result in expanded usage. Productive varieties with improved oil and/or protein quality would increase value of oil and protein.

Recommended Research Effort:

1972	1977
40	64

GROWTH REGULATORS FOR SOYBEANS

RPA 307-G

Situation: Growth regulating chemicals have been approved for a few specific uses in crop production. More will be available in the future. These chemicals may stimulate plant growth or control plant behavior in ways that make crops better suited to needs. The influence of a limited number of growth regulators on floral development in soybeans has been investigated and at least one promising lead has occurred. However, the usefulness of many existing growth regulating substances on soybeans has not been investigated.

Objective: To find growth regulators that will consistently increase yields and be economically feasible for use in soybean production.

Research Approaches:

A. Screen chemicals to identify compounds which can increase soybean yields.

B. Determine concentration limits of growth regulators through studies of rates and methods of application as related to other elements of the management system.

C. Determine the significance of wetting properties of solutions, nature of leaf surfaces, drying conditions, degree of coverage, and physiological status of the plant on the effectiveness of a foliar application.

D. Investigate the possibility of supplying growth regulators to the plant through a soil application.

E. Conduct basic metabolic studies to identify reactions or systems which might be modified with growth regulators to increase yield.

Potential Benefits: Increase soybean yields and possibly extend area of adaptation.

Recommended Research Effort:

1972	1977
8	10

MECHANIZATION OF SOYBEAN PRODUCTION

RPA 308

Situation: Machinery used in soybean production is hard to operate with maximum effectiveness. Machinery problems sometimes cause farmers to plant soybeans too deep or at undesirable rates. Equipment for cultivation or herbicide application frequently damages the crop. Combines cause field losses up to 15 percent, plus major damage such as broken or cracked beans. Adjustments to equipment are imprecise and hard to make. Continuous adjustment may be needed due to uneven terrain or variability in soil characteristics.

Objective: To develop equipment principles which will make it possible to reduce planting and harvesting costs, and to reduce the number of operations required in soybean production.

Research Approaches:

A. Investigate alternative means of controlling planting depth and rates to insure optimum seed placement.

B. Continue efforts to reduce numbers of operations required to produce the soybean crop; adapt or develop equipment for better application of herbicides.

C. Develop sensors to scan the crop ahead of planting and harvesting mechanism to signal and control machine adjustments.

D. Improve components of harvesting mechanisms to permit more efficient entry of plant into machine, automated adjustment, and higher quality threshing and separating.

E. Coordinate with research in 209-A, 307-A, -B, -D, and - E.

Potential Benefits: Much of the benefit of mechanization research will be realized through better weed control, fertilization, and water use practices. In addition to benefits in other RPAs, savings due to lower seed requirements and reduced harvest losses would lower unit production costs and maintain quality.

Recommended Research Effort:

1972	1977
3	3

SYSTEMS ANALYSIS FOR SOYBEAN PRODUCTION

RPA 309

Situation: Soybean producers must choose among many alternatives for selection of varieties, planting times, row spacing, plant populations, size and capacity of machinery, and time and amount of fertilizer, irrigation, and weed control practices. The proper selection from these alternatives would provide for optimum use of labor, capital, and machine capacity as influenced by weather probabilities, field condition, and time. Mathematical models are needed to simulate the variables and alternatives in the production system in order to compare the profitability of various alternatives. Systems analysis for soybeans should be a part of more broadly based analyses for entire farm enterprises including several crops and livestock. The more varied the enterprise, the greater are potential benefits from systems analysis.

Objective: To combine that set of production practices, capital investments, and labor availability that will optimize income from soybean production on individual farms.

Research Approaches:

A. Adapt or develop and use mathematical models for simulating the soybean production system to identify factors requiring additional research.

B. Test hypothetical systems of utilizing all known resources to produce maximum yields. Simulated differences in varieties, nutrients, water, herbicides, and other elements of management practice will be compared to determine most productive and economical combinations.

Potential Benefits: Benefits will be realized in many areas due to more effective use of management resources leading to reduced unit production costs.

Recommended Research Effort:

1972	1977
4	4

PRODUCTION OF SOYBEANS WITH IMPROVED QUALITY

RPA 405

Situation: Quality problems in soybeans relate to total oil and protein content, amino acids, fatty acids, flavor stability, and constituents of significance in phenomena such as flatus. Except for total oil and protein, progress in producing soybeans with increased processing or product quality is limited by lack of knowledge as to the cause of poor quality or the identity of significant constituents, or by analytical methodology which in some cases is inadequate to support a breeding program.

Objective: To develop varieties or practices to produce soybeans of improved processing quality, nutritive value, or flavor stability; to increase oil and protein at the expense of carbohydrates; and to develop suitable techniques for measurement of chemical constituents or other factors which may be critical in processing or in the use of soybean products.

Research Approaches:

A. Identify genotypes containing significant chemical constituents in higher or lower than normal concentrations and use such genotypes to breed agronomically superior varieties with superior composition.

B. Determine the significance of environmental factors during crop production on the levels of chemical constituents of special significance in processing quality, consumer acceptability, animal nutrition, and flavor stability.

C. Devise new or modified analytical techniques appropriate to support Approaches A and B.

Potential Benefits: Increased supply of highly nutritious food. Improved protein balance, elimination of linolenic acid, and elimination of factors causing flatus and other undesirable effects would result in increased value and savings in processing costs.

Recommended Research Effort:

1972	1977
10	10

C. Product Development - Goal IV

In the "National Program of Research for Agriculture," under Goal IV, the objective is to expand the demand for farm products by developing new and improved products and processes and enhancing product quality. Within this objective the research effort would be aimed at (1) developing varieties and strains of crops having attributes that meet the preferences and desires of consumers; (2) improvement of production practices, processing methods and marketing procedures so as to preserve or enhance inherent qualities of farm products; (3) development of new and improved products from agricultural commodities by tailoring products to meet customer preferences.

The objective was further broken down into 12 research problem areas of which three will be discussed in this section: RPA 406, New and Improved Food Products; RPA 407, New and Improved Feed and Industrial Products; and RPA 408, Quality Maintenance in Marketing. RPA 405, pertaining to production for consumer acceptability is discussed in the previous section.

Much of the research in this goal contributes to the success of other goals. The success of U.S. products in foreign markets depends in part upon their quality. This research contributes to consumer health and well-being. Also it provides basic information for the improvement of grades and standards, and, by increasing the shelf life or by reducing the bulk of products, it reduces the cost of marketing. As product development increases demand and market outlets, it contributes to the level of living and the prosperity of rural communities.

NEW AND IMPROVED SOYBEAN PROTEIN FOOD PRODUCTS

RPA 406-A

Situation: Soybean protein products have high nutritional value, as is shown by their extensive use in livestock and poultry feed. Comparatively little use is made of soybeans in the human diet. Low-cost foods that are highly nutritious and dietarily attractive are needed not only in the United States but throughout the world. Their formulation and use must be based on available commodities, nutritional requirements, and consumer acceptability. Many inexpensive soybean food products need improvement for consumer acceptability. Improvements in flavor, physiological activity, and texture are needed to achieve greater use and consumer acceptance. Procedures now available probably make it feasible to identify flatus and flavor precursors.

Objective: To obtain greater consumer acceptance of soybean protein food products.

Research Approaches:

A. Identify flatus and flavor precursors in soybeans.

B. Investigate enzymatic methods of removing or modifying undesirable factors.

C. Determine the relationship of composition and structure of soybean protein products and their combinations with cereal products to the nutritional and physiological responses of humans.

D. Cooperate with industry in A, B, and C, and in evaluating procedures developed in this research.

Potential Benefit: Soybean protein products, such as full-fat or defatted soy flour represent the lowest priced source of high quality protein for human consumption. At least 1.5 to 2 billion people in the world do not have enough to eat. The potential of soy products to meet food needs in the United States and the world is enormous. Without low-cost procedures to improve acceptability of these products, this potential is not likely to be achieved.

Recommended Research Effort:

1972	1977
20	26

OIL STABILITY

RPA 406-B

Situation: Soybean oil is the major food fat in the United States, but its use in both foreign and domestic markets can be increased by improvements in flavor stability. Important areas where additional improvement is desirable are primarily in the liquid oil, including use as a cooking and salad oil, and as an ingredient of solid or semisolid products. Although linolenate is known to be a major factor in the flavor problem of soybean oil, other components appear to be secondary factors and their identity and effects must be determined. Surpluses of oil over domestic needs have averaged over one billion pounds during the last 8 years. Increased production of soybeans, greater meal use, and a decline in hard currency markets for oil will increase supplies. Increased research is needed to make improved edible products available in all markets.

Objective: To devise methods of chemically treating soybean oil to provide a more stable oil for use in cooking and salad oil and as a liquid ingredient of margarine.

Research Approaches:

A. Develop superior catalytic and chemical methods to stabilize soybean oil from the effects of linolenate esters. Better methods will be sought to hydrogenate selectively the linolenate esters to compounds more resistant to oxidative deterioration. Studies on a large scale will be conducted in cooperation with industry to determine the practicality of laboratory developments.

B. Devise superior methods of determining flavor stability.

C. Identify volatile flavor products other than linolenate derivatives.

Potential Benefits: More extensive domestic and foreign use of soybean oil as a cooking and salad oil and as an ingredient of soft margarine and shortenings.

Recommended Research Effort:

1972	1977
18	18

NEW AND IMPROVED INDUSTRIAL PRODUCTS FROM SOYBEAN OIL

RPA 407-A

Situation: About 10 percent of total domestic disappearance of soybean oil, or 500 million pounds, goes into nonfood uses. About 100 million pounds goes into resins and plastics, 100 million pounds into paints and varnishes, and the rest into other uses including chemicals, special lubricants, and soaps. Utilization research has resulted in the development of markets for epoxidized soybean oil. Additional opportunities exist because the total usage of synthetic organic chemicals, coatings, and related materials is increasing. Soybean oil has found use in these nonfood products because it is a high volume low-cost material. Increased stocks of oil will result from greater production of soybeans, larger use of meal, and a decline in hard currency markets for oil. Competitive nonfood products will help stabilize price and increase outlets in domestic and foreign markets.

Outlets for industrial organic chemicals in plastics, agricultural chemicals, and related industries totaled more than 10 billion pounds in 1964. Previous successes with dimer acids, polyamide resins, and epoxidized soybean oil have shown that soybean oil can share in these increasing outlets for chemicals.

Objective: To increase nonfood uses of soybean oil by chemical modification; to produce new or improved products or chemical intermediates; to evaluate new materials in various applications.

Research Approaches:

A. Develop and test new plastics, resins, coatings, and other new and improved nonfood products or processes.

B. Evaluate new products and processes for specific uses.

C. Adapt procedures for chemical modification of promising products to continuous low-cost processing.

Potential Benefits: New outlets for soybean oil in nonfood uses should increase the total farm income. Such outlets help stabilize prices by diversification of markets.

Recommended Research Effort:

1972	1977
11	11

IMPROVED FEED USE OF SOYBEAN MEAL

RPA 407-B

Situation: The composition of soybean meal is known to vary but the extent of variation is not known. Specific data on significant feed constituents is essential if maximum benefit is to be received from computer-control of feed formulation. Laboratory methods are now available for determination of key ingredients such as minerals and amino acids. More rapid analytical methods are needed for computer-control of feed formulation to achieve optimum use of soybean meal.

Objective: To obtain new information on, and develop rapid methods for, the analysis of soybean meal for key feed ingredients.

Research Approaches:

A. Analyze soybean meal of several varieties produced at several locations and by several processes to determine the effect of genetic, location, and processing variables on the value of meal for feed purposes.

B. Develop analytical methods that are rapid and simple enough to be used in feed formulation.

Potential Benefits: Nutrient economies based on actual composition of soybean meal will permit more efficient production of swine and poultry. The value of any saving in formulation will be reflected in the gross income or farm value of products.

Recommended Research Effort:

1972	1977
10	13

QUALITY MAINTENANCE OF SOYBEANS AND THEIR PRODUCTS DURING MARKETING

RPA 408

Situation: Soybeans and their products are subject to deterioration in quality with resultant economic loss between the time of harvest and ultimate use. Information is needed on the effect and control of temperature, humidity, and atmosphere in storage. Methods are needed to detect chemical residues and other quality deteriorating factors.

There is need for detection and control of insects during storage and marketing.

In order for grades and standards to be useful in buying and selling by description and to have economic differentials based on varying levels of quality, rapid and accurate objective measures of quality attributes are needed.

Objective: To determine optimum environmental conditions for soybeans and their products during the marketing process.

Research Approaches:

A. Develop techniques, instruments, and procedures for detecting and measuring chemical residues, presence of insects, and other contaminants affecting quality.

B. Develop practical and objective methods of determining quality attributes.

Potential Benefits: Reduction in quality and product loss during marketing. The results of this research should facilitate marketing transactions through more accurate description of products and more precise measurement of quality attributes.

Recommended Research Effort:

1972	1977
4	6

D. Efficiency in the Marketing System - Goal V

In the "National Program of Research for Agriculture," the part pertaining to marketing is contained in Goal V, "Efficiency in the Marketing System." Under this broad goal for all of agriculture are the following objectives: (1) to provide farmers with better market guides in making production and marketing decisions; (2) to improve quality and availability of production items and services; (3) to facilitate distribution of products; (4) to improve the quality and availability of products to the consuming public; and (5) to reduce the resources required in the transfer of products from farm to consumer.

These objectives were broken down further into 10 research problem areas of which two were assigned to this task force. They are RPA 501, Improvement of Grades and Standards; and RPA 504, Physical and Economic Efficiency in Marketing Field Crops.

The marketing system is in a constant state of change. In an ideal marketing system, buyers and sellers would have complete knowledge of all the factors affecting transactions; consumers would be provided exactly what they want; product quality would be measured by objective methods and described in simple terms. There would be competition between many sellers and many buyers so prices would be at equilibrium levels determined by the forces of supply and demand. Handlers and processors would be able to communicate with each other and with producers and consumers in understandable terminology to describe product attributes. Prices would reflect value differences of well-defined gradations of quality.

Excellent and immediate communication between traders in soybeans and soybean products is now achieved at the Chicago Board of Trade. Grades and standards used in trading, however, are limited almost entirely to physical attributes. Quality factors relating to oil, protein, and their constituents are not directly considered, except for protein content of soybean meal. The flow of information to growers and to many handlers is insufficient to provide complete knowledge of all trading factors.

To help improve the marketing system and assist in the development of national policy, research is needed on matters ranging from individual transactions at any point in the marketing system to international trade. In this section we consider the need for research on the economic aspects of grades and standards, and on physical and economic factors as they relate to efficiency in the marketing system. The need for research on chemical methods required to implement such standards is discussed in the preceding section on Goal IV.

IMPROVEMENT OF GRADES AND STANDARDS

RPA 501

Situation: Grades and standards in the marketing system should provide meaningful communication with respect to quality of a product in relation to its price. Objective, quick, and accurate measures for characteristics of economic significance are needed, along with increasing automation in the use of this information. Most soybeans are traded in the U.S. on the basis of official grades, which are determined by test weight per bushel, moisture, splits, damaged kernels, and foreign materials. Oil and protein content are not factors in the grading system. The producer of high oil or high protein soybeans is underpaid and the producer of soybeans with inferior composition is overpaid. Low cost and accurate methods of testing for oil and protein at country buying points are not now available. A system of grades recognizing oil and protein content would require such methods. Provision for research to develop such methods is included in RPA 405.

Objective: To provide grades and standards that will effectively communicate value differences for varying gradations of quality.

Research Approaches:

A. Evaluate the effectiveness of existing grade standards in serving the needs of sellers and buyers and reflecting different gradations of quality which affect value and use.

B. Determine the need for grade standards for the many new soybean products and those to be developed in the future for which grade standards do not exist.

C. Develop descriptive terminology for grade standards which will characterize the different attributes of soybeans and their products so as to facilitate communication between buyers and sellers.

D. Establish a uniform system of grades recognizing those characteristics which reflect value and affect use.

Potential Benefits: Improved communication through more precise terminology for describing varying gradations of quality. Prices would more accurately reflect value.

Recommended Research Effort:

1972	1977
1	1

PHYSICAL EFFICIENCY IN MARKETING SOYBEANS

RPA 504-A

Situation: Physical efficiency pertains to structures, equipment, containers, devices, work methods, and operating procedures used in assembling, processing, packaging, transporting, storing, and distributing. Improved techniques and equipment are needed for economically handling, conditioning, and storing soybeans in marketing channels. Physical damage to products lowers the quality. Likewise excess moisture and mold affect quality. Storage and labor are important marketing costs. Transportation has had a significant influence on the development and location of the soybean-processing industry. The practice of granting "milling-in-transit" privileges to soybean processors at specific locations has limited the use of trucks for moving soybeans to processing plants. Recent changes in transportation include enlarged hopper railroad cars and multiple-car or full-train shipments.

Objective: To bring about the most effective flow of soybeans through marketing channels, including processing activities, that will result in products in the form, time, place and quality most desired by consumers.

Research Approaches:

A. Determine relationship of equipment design, plant layout, and handling methods for conditioning, storing, and other activities on product quality and marketing costs.

B. Develop new or improved equipment for handling, storing, conditioning, and otherwise preparing for the next step in marketing to improve the quality of product and reduce marketing costs.

C. Determine the effect of transportation equipment design and performance and methods of transportation on marketing and processing costs, product loss, and end product quality.

D. Develop packaging and transportation methods and techniques to maintain product quality and reduce transportation costs.

Potential Benefits: Reduce the total costs of conditioning, storage, processing, and distribution of the national soybean crop and maintain the highest quality of products.

Recommended Research Effort:

1972	1977
5	6

Note: The above SMY allocation includes RPA 504-B.

ECONOMIC EFFICIENCY IN MARKETING SOYBEANS AND THEIR PRODUCTS

RPA 504-B

Situation: In most transactions between buyer and seller the negotiation has three important elements--quantity, quality, and price. The price is determined by the other two elements and is the common denominator of most marketing transactions. As products flow through the marketing system a series of activities that affect price take place. Competition, market information, and consumer attitudes affect price. Effectiveness of the pricing system depends largely on how rapidly and accurately prices reflect such factors as weight, grades, quality, and other price determinants, and how rapidly and accurately producers, processors, and others can evaluate and act upon this information.

An understanding of consumer reactions and reasons behind them is essential to planning improvements in the production, processing, and marketing of soybeans and their products, and for developing educational programs, setting or revising grades and standards, or evaluating new products.

Objective: To provide a continuing evaluation of economics of the marketing system for soybeans with special emphasis on market organization, competition, pricing, market information and communication, equity, and consumer preferences.

Research Approaches:

A. Evaluate the overall structure and performance of soybean markets including studies of prices and marketing costs, transportation rates, margins, competition, market information, practices, and services.

B. Evaluate the economic impacts of marketing innovations, new or improved products, and market development activities on soybeans and their products in both domestic and foreign markets.

C. Evaluate the availability of price information, its communication to buyers and sellers, and its usefulness in guiding production.

Recommended Research Effort:

See RPA 504-A.